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Georgius Prochaska: A Pioneer in Modern Physiology (1749-1820)

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GEORGIUS PROCHASKA, Czech anatomist and physiologist of the period of enlightened despotism, is not unknown to the medical men of this country. We may say that his name was almost familiar, mainly among neurologists, just over a hundred years ago, when it was involved—nearly twenty years after Prochaska's death—in the bitter controversy over the originality of discoveries and conceptions of the reflex action of the eminent British neurologist and neuro-physiologist, MARSHALL HALL. Shortly after Hall published his two famous Memoirs on the Nervous System (1837), JOHN DURANCE GEORGE, one of the presidents of the Medical Society of University College, London, read, at its meeting on March 30, 1838, a paper on the History of the Nervous System, in which he pointed out, from the material reviewed, that Marshall Hall had been anticipated in most essential phenomena, as well as in their interpretation, claimed as original, by several earlier authors. He quoted Professor SHARPEY to the effect "that of all previous physiologists Prochaska had approached most nearly in his views to those at present entertained," and remarked that "in Dr. Hall's account of the 'Opinions of Former Physiologists' no such author is mentioned or even alluded to," and after a review of earlier contributions gave long quotations from Prochaska and compared his statements with those of Marshall Hall, pointing out their striking similarity. The editorial comment of the London Medical Gazette, where George's paper was published, contains a still sharper attack:

" . . . It is a very remarkable fact, as stated by Mr. George, that Dr. Hall, though he has published the Opinions of Former Physiologists, makes no mention of the author above-named, and certainly this fact will not be regarded as less remarkable when we inform our readers that there is a copy of Prochaska's work in the library of the Medical and Chirurgical Society, and that little as the volume was known to the others, one member at least has shown that he fully appreciated its value, by the fact of his having repeatedly taken it out: that member, need we add, is—Dr. Marshall Hall."

Thereafter Marshall Hall produced a letter from the librarian of the Medical and Chirurgical Society stating that he had borrowed Prochaska's works in 1835, 1837 and 1838, whereas his first two papers on that subject were read in November 1832 and June 1833. But the controversy did not end there, and Hall's opponents remarked that he did

not mention Prochaska even in the papers published in 1837. We do not intend to discuss this controversy; the original contributions of Marshall Hall to nervous physiology, as well as his somewhat exaggerated claims, were discussed by Sir CHARLES SHERRINGTON, and the controversy was critically reviewed more recently by F. FEARING. We should like only to recall here the great personality of Prochaska, and to give some information on his life and work.

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PROCHASKA was born on April 10, 1794, at Blížkovice, a village in Moravia, and was one of the seven children of a poor village smith and farmer. Because of his slender physique he was not thought suitable to take up his father's professions, and so he was sent to the Gymnasium at Znojmo, probably with the intention of his becoming a church minister. As a student he had a very hard time, and had to earn his living as a private tutor to his fellows from wealthier families. At the age of fourteen he was narrowly saved from death by asphyxia, to which two other boys, his room mates, succumbed, poisoned by coal gas. He is said to have gained thus more sympathy and help, and later, when at the Lyceum of Olomouc reading for his "Philosophy" course, he was supported by his relative, a canon of Olomouc Chapter.

As a student he is said to have been interested mainly in physics and mathematics. He was also very keen on music and painting, and maintained an active interest in the arts during his whole life. After he took his degree in Philosophy he went to Prague, where he made his theoretical medical studies, and later, in 1774, to Vienna, where he became assistant to the famous clinical doctor, Professor DE HAEN, a countryman of the great reformer of medical teaching in Austria and founder of the first great medical school at Vienna, VAN SWIETEN (†1770). He took his degree in 1776, and the same year, after DE HAEN's death, became assistant of the Maltese JOSEPH BARTH, Professor of anatomy, physiology and ophthalmology. Barth was apparently very fond of his collaborator—four years younger than himself; besides their common scientific interests, they were both interested in the arts, and through Barth's mediation Prochaska became, in 1778, extra-ordinary Professor of Anatomy and Physiology, and the same year, having taken the degree of Magister of Ophthalmology, he took over the vacant chair of the three mentioned subjects at Prague. He remained in Prague for thirteen years, and published there, in 1784, in his *Adnotationes Academicæ*, his most famous work *Commentatio de functionibus systematis nervosi*, to which we shall refer again later on. He was also among the early members of the *Societas Scientiarum Regni Bohemiæ* (*Königliche böhmische Gesellschaft der Wissenschaften*), which started in 1780, at first as a private Society of a few Czech scholars, and published several shorter papers in its *Abhandlungen*. He also established in Prague an anatomical collection, in which HYRTL, when taking over the anatomical institute in Prague in 1837, found "many valuable things."

In 1791, when Professor Barth retired, Prochaska succeeded him in Vienna, where, since 1805, he restricted himself to the teaching of "higher" anatomy, physiology and ophthalmology.

It is interesting that Prochaska still lectured in Latin even during the last decade of his career, although already at the time of Josephine's reforms the vernacular—which meant German under

the old Monarchy—was generally substituted for the former international Latin, and indeed in the early 19th century all subjects, with the exception of Physiology and *materia medica* (where Latin seemed more appropriate to the subject) were read at the University of Vienna in German.

Prochaska had, both in Prague and later in Vienna, an extensive ophthalmic practice, and is reported to have made over 3,000 cataract operations—quite an impressive figure for that period, considering that it surpasses that of the famous founder of the Viennese Ophthalmological School and Prochaska's rival JOSEPH BEER, who devoted himself entirely to ophthalmology. Prochaska's main scientific interests were, of course, elsewhere, and we find in his voluminous literary work just one paper on eye affections (MOHRENHEIM'S *Beytraegen*, 1783), though he gained an important reputation as an ophthalmologist. Hyrtl remarks that Prochaska's motives for practising were quite different from those which inspired his other work, that he was lead by the old dictum "*Dat Galemus opes.*" But we have to mention that he had also many poor patients free of charge.

Prochaska retired in June 1819 after a long and successful career, rewarded by the acknowledgment of the scientific societies and distinctions of the Court. He died next year, on July 17, 1820, in Vienna, leaving behind him quite a voluminous literary work: its list compiled in this country and possibly not quite complete, contains 31 titles—17 papers and 14 books, of which four are in two volumes and one in three editions.

Prochaska's contributions to anatomy and physiology are much more interesting and valuable, and grant him a significant place in the history of these sciences. Joseph Hyrtl, undoubtedly the greatest personality among Prochaska's successors in the Chair of Anatomy at Prague and Vienna, had a high opinion of his anatomical work, and praises him as "the first and only Viennese anatomist who left behind him a deep and lasting trace of his activity. . . He was, what practical anatomists so seldom are: a thinker." This appreciation is the more significant as Hyrtl plainly expressed his sarcastic and pungent judgments about many others of his predecessors, and did not spare even Prochaska from some cutting remarks on his weak points.

Prochaska's contribution is not limited to the naked eye anatomy, and his microscopic studies, as KÖLLIKER mentions, rank him among those few scientists of the 18th century who are rightly regarded for their outstanding contributions as pioneers of histology.

Many other prominent scientists—LONGET, PFLÜGER, VULPIAN, NEUBURGER, FEARING and others—expressed similar appreciation of his contributions to physiology. It is, however, hardly possible to draw a line dividing his contributions to anatomy from those to physiology. Anatomy was for him more of a stepping-stone, a basis for the understanding and interpretation of different bodily functions, which he followed from both morphological and physiological aspects. We can see that, for example, in his best known series of anatomical research, viz., in the

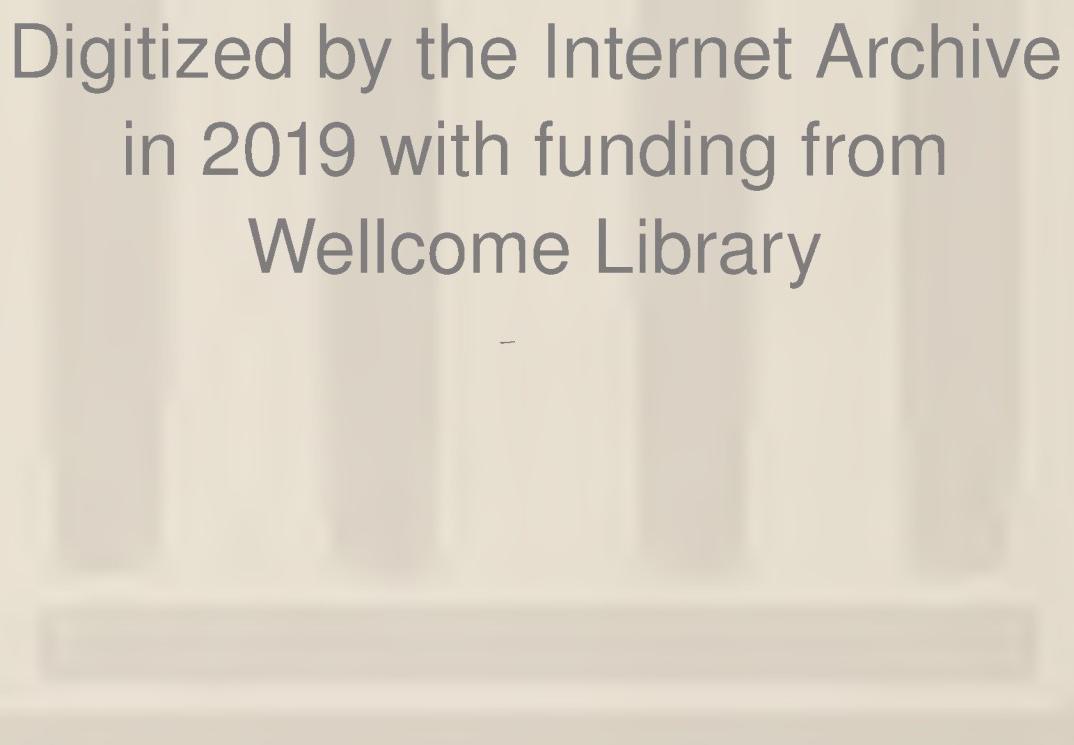
morpnone of the distribution of blood vessels in different tissues and organs. Prochaska learnt from Barth a method of injecting blood vessels, a method previously used by RUY SCH and LIEBERKÜHN, and lost after the latter's death, because he had kept it secret. Reinvented by Barth, this method was brought by Prochaska to greater perfection and used by him not only for the study of the blood and lymphatic vessels, but applied also to the investigation of the course of seminal tubules and of the ear cavities. His collection of injection preparations in the museum of the Institute of Anatomy was very famous and greatly admired by foreign medical visitors, as is testified by several contemporary travel and correspondence publications. One of these visitors, in 1814, the distinguished British physician, RICHARD BRIGHT, writes in his "Travels from Vienna to Lower Hungary, etc." :

"There is yet one more cabinet of this class of preparations, which is particularly worthy of attention. This is the museum of Professor Prochaska, which contains the most minute injections of the vessels of the human body in existence. In fact, the Professor is in possession of a certain art of injecting, which he received from Barth, on condition of secrecy, and thus, in defiance of all the rules of philosophic liberality, these two enlightened men deny to the world the valuable means they have discovered of increasing our knowledge of the most intricate parts of the human frame. In the meantime, Prochaska is ready, for fifty ducats, to supply to the curious small cabinets, accompanied with a microscope, and containing about seventy microscopic specimens, showing the most minute ramifications of different vessels in the various structures of the body. It appears that this art of subtle injection is the same which Lieberkühn employed before them, and which was lost after his death. It would, indeed, be a blot upon the scientific spirit of the university of Vienna, if a second time such a discovery should be suffered to perish."

There was, however, no serious reason for these apprehensions : the method was widely used and highly perfected by Barth's and Prochaska's followers during the 19th century, mainly by Hyrtl, who summarised the results in his classical book. The "art of subtle injection" did not perish and the world was not denied the valuable means of increasing the knowledge of the most intricate part of the human frame. And Prochaska's research on these subjects was the part of his scientific work most appreciated by his contemporaries. His descriptions of the distribution of the blood vessels in the intestine confirmed and completed the earlier findings of Lieberkühn. Prochaska was the first to give an accurate picture of the blood vessel ramifications up to the very minute ones in the muscles. His technique of injecting capillaries was considered then extremely fine and enabled him to give the most detailed description of the time of their course and ramifications.



(G. PROČÍNSKÝ)



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This anatomical investigation was for him the starting point of a conception of the nutrition of tissues, developed in detail in his monograph *Bemerkungen über den Organismus des menschlichen Körpers, etc.* (1810). He emphasised the importance of blood supply for muscular activity and pointed out that blood circulation plays an important part in the absorption of certain tissues and organs which, having been necessary at one stage of the development, are replaced at a later stage by others more expedient. So he developed a theory of bone ossification, where he rightly insists that it does not occur by a mere hardening or transformation of the cartilage into bone, but that the former is driven back and "destroyed" by the bone formed and growing in its midst. And he points out the coincidence of this process with the growing of blood vessels in the ossification area.

We cannot deal here with all the other noteworthy contributions of Prochaska to the macro- and microscopical anatomy of different organs, but we may still mention his descriptions and pictures of the elementary muscle fibre, sarcolemma and striation in voluntary muscles (*De carne musculari*, 1778); in his other early anatomical treatise, *De structura nervorum* (1778), we learn that he knew neurolemma (often called "Schwann's sheet"). He gives the first accurate description (with drawings) of the olfactory bodies, and he first drew the important parallel between the *portio major* and *portio minor* of the fifth cranial nerve and the posterior and anterior roots of the spinal nerves:

"Quare omnium cerebri nervorum solum quintum par post ortum suum more nervorum spinalium ganglion semilunare dictum facere debet, sub quo peculiaris funiculorum fasciculus ad tertium quinti pari ramum, maxillarem inferiorem dictum, properat insaluto ganglio semilunari ad similitudinem radicum anteriorum nervorum spinalium?"

That was an important observation, and Prochaska undoubtedly suspected that this anatomical arrangement and the striking parallel between the spinal and trigeminal roots in their relation to the spinal and Gasserian ganglia had some functional significance. It is amazing how nearly he approached to the fundamental discovery of the difference in conduction of anterior and posterior roots, established later by CHARLES BELL and FRANÇOIS MAGENDIE. Already in his anatomical treatise, *De structura nervorum*, he assumed the existence of separate centrifugal and centripetal nervous fibres, but it was only in later years that he speculated about the possibility of this functional dualism corresponding to the anatomical dualism of anterior and posterior roots. ("an per unam radicem sursum et per alteram deorsum propagatio fit?" *Disquisitio*, p. 75, 1812.)

If he did not actually discover this most important phenomenon, he has at least the merit of having foreshadowed it, and having prepared the way for his more fortunate followers.

But his contribution to the understanding of the nervous system—"the most important of all organs in the animal economy"—did not end with his anatomical study, and, as with his work on blood supply, the anatomical research was followed by physiological studies, experiments and conceptions. He carried out this work at Prague—he went there in 1778, the year *De structura nervorum* was published—and probably found there more interest in these problems, as his predecessor KLINKOSCH with his collaborators (TRZEBICZKY, GRUBER) had been engaged in studies of irritability and sensibility raised by the work of HALLER. Six years later he published the results in his most important and best known treatise *Commentatio de functionibus systematis nervosi* included in the third part of his *Adnotationarum academicarum* (Prague, 1784), where he formulates his general conception of nervous activity including the theory of reflex action. This little book is a real masterpiece, remarkable for its clarity of style and systematic presentation of all the then known material, which is analysed and discussed in a true scientific spirit, quite exceptional and outstanding in the contemporary nervous physiology. It is true that many fundamental facts concerning the reflex action had been already established and that several theories of the nervous reflexion had been formulated by his predecessors (DESCARTES, WILLIS, WHYTT, UNZER and others). It is equally true that Prochaska in his own experimental work did not make a distinctive original contribution to the reflex theory. That could hardly be expected; his formation and the method of his work were those of an anatomist, not in the line of experimental work, as it developed in the later generation and characterised the 19th century as a period of great discoveries in physiology. But his logic was that of a physiologist, and we can say that at that time an unprejudiced analysis and discussion of the known facts was more needed than new experimental facts, which could not have been properly interpreted without the former. We see indeed that the current doctrines of nervous physiology were still influenced—if not dominated—by the ideas of the mysterious nervous fluid and animal spirits, in spite of serious objections and doubts raised by a few rational minds. Prochaska, who thoroughly mastered the contemporary knowledge, was very sceptical about these and other conjectures and hypotheses *a priori*, which could not be tested by experiments,

convinced that they were more harmful than useful obscuring the truth. He attempts therefore to explain nervous activity by facts only—*per mera facta*. This approach to the problem is clearly formulated in the Introduction :

"After all the earnest attempts of the greatest philosophers and physicians from the earliest ages, to explain the functions of the nervous system, we can hitherto only say with Haller, it is but a little we certainly know, that much remain unknown, and if we may judge of the future by the past, that not little will remain unknown for ever. Nevertheless, I do not think all hope should be abandoned, especially if we should be able to detect and remove the cause of that slow progress hitherto made; and in this, in my opinion, this partly consists in the difficulties of the subject, which nothing but great labour can overcome; and partly in the love of hypotheses, which have been devised to explain the functions of the nervous system. Many, content with these false resemblances of truth, neglect to inquire into the truth itself, and they who do investigate, unless they discard the prejudices which may spring from hypothesis, often fail to perceive the truth, even when it is plain before them.

I have, therefore, entered on this attempt, to explain the natural functions of the nervous system, without any hypothesis, and by simple facts only; . . ." (T. Laycock's translation, Sydenham Society, p. 364, London 1851).

And further, after a discussion of previous observations, experiments and theories, he expresses himself even more plainly :

"At length we abandon the Cartesian method of philosophising in this part of animal physic also, and adopt the Newtonian, being persuaded that the way to truth through hypothesis and conjectures is tedious and altogether uncertain, but far more certain, more excellent, and shorter, through the inductive method (p. 380).

Then he explains in what sense he uses the older term, *vis nervosa*, which is one of the main features of his conception :

"Newton designated the mysterious cause of physical attraction by the term of *vis attractiva*, observed and arranged its effects and discovered the laws of motion; and thus it is necessary to act with reference to the functions of the nervous system: we will term the cause latent in the pulp of the nerves, producing its effects, and not as yet ascertained, the *vis nervosa*: we will arrange its observed effects, which are the functions of the nervous system, and discover its laws; and thus we shall be able to found a true and useful doctrine, which will undoubtedly afford a new light, and more elegant character to medical art." (p. 380).

And in 1800 he explains his position again in the Address to the Reader in the second edition (*Opera minora II.*) :

"I had already published this dissertation in the third fasciculus of my *Adnotationes Academicæ*; at which time many philosophers and the distinguished TISSOT himself, still used the hypothesis of the nervous fluid, to explain the functions of the nervous system in accordance with the opinion of BOERHAAVE. Convinced of the insufficiency of this hypothesis, I resolved to use the inductive method in this dissertation, and explain those functions by facts only; using the term *vis nervosa* to designate

that agent (as yet unknown) by which the nervous system is rendered fit for the performance of its functions, and which I have used more extensively in my public lectures, and in my textbook of human physiology (*Lehrsätze aus der Physiologie des Menschen*, 1797)." (Ibid, p. 380).

He explains then the properties of *vis nervosa*, i.e., "the aptitude of the nerves to receive impressions and, when received, of transmitting them either way with great rapidity" (p. 407 l.c.), "which (impression), when it arrives at the brain, produces the perception of a sensation, but when it arrives at the muscle, excites its contraction" (p. 408). According to Prochaska, *vis nervosa* is latent, "until another exciting cause, which we call stimulus, is brought to bear," this stimulus being corporeal (mechanical) or mental "present in a portion of the nervous system, and by means of this portion controls the rest of the nervous system, and the rest of the body, as far as it is allowed." The *vis nervosa* is graded in strength—the response being related, within certain limits, to the strength of the stimulus, and to the conditions of the nervous system. Further, *vis nervosa* is divisible, i.e., exists in nerves independently of the brain. We can see thus, that this conception resembles very closely the modern idea of nervous impulse.

Another important feature of Prochaska's theory of reflex action is the conception of *sensorium commune*—the part of the nervous system, where consensus between the sensory and motor nerves takes place—which he locates, after a thorough discussion, as extending "through *medulla oblongata*, the crura of the cerebrum and cerebellum, also part of the *thalami optici*, and the whole *medulla spinalis*; in a word, it is co-extensive with the origin of the nerves" (l.c. p. 430), to where also later the reflex centres have been located.

He insists on the automatic nature of the nervous reflexion, which is uncontrolled by the will, takes place with or without consciousness, and has an evident purposeful character; "the general law by which the *sensorium commune* reflects sensorial into motor impressions is the preservation of the individual."

It would be most interesting to give more quotations and discuss more in detail the different important points in Prochaska's conception of the reflex action; that would, however, be outside the scope of this short article. We hope that even the few examples we have given illustrate sufficiently the statement that Prochaska really succeeded in his rational analysis, not only in putting the existing knowledge into shape, but also in foreseeing the new developments and anticipating some of the basic properties of the nervous system—logically necessary in his thesis, but established by

experimental proofs only many years later. The examples and quotations show also, we hope, how important was the service rendered by Prochaska to the nervous physiology by sweeping away the old erroneous doctrines, which obscured the truth and hindered the progress in this important branch of physiology. We can see in his conception a basis on which the modern conceptions could have been built and new discoveries brought into proper light.

Prochaska had a similar rationalistic approach to the other phenomena of life, and in the five editions of his textbook of physiology he insists on the necessity of considering "the so-called vital forces not as some special forces peculiar to living organisms, but as the common forces of Nature, which are however combined and interrelated one to another, and as their relations are not yet known, it is for the time impossible to find out their different respective actions." This is again the Newtonian approach, an attitude which enabled the progress of biology at its great epoch. And Prochaska was one of the few who preached it at its dawn and who prepared the way for the others.

But the reader may ask himself whether we are not overrating the importance of Prochaska's contribution. Indeed, ECKHARD in his detailed critical history of reflex action (1881) does not greatly value Prochaska's contribution, remarking that its importance had been greatly exaggerated by his contemporaries. This opinion has often since been quoted, without being tested. Eckhard, a distinguished physiologist of the 19th century—the period of great experimental work—regards the contribution mainly from the point of view of discoveries, of new experimental facts, which in Prochaska's case were not impressive. Science, however, is not only an accumulation of new observations, the increasing of the body of knowledge, but rather their grouping into an ordered and intelligible system based on general principles derived from them. Sometimes a true scientific approach and analysis, the removal of a false doctrine, has been far more important than dozens of new observations. The view of the alleged exaggeration of Prochaska's contribution by his contemporaries cannot be held either. They appreciated the other work of Prochaska (mainly his injections of vessels as we see in the case of R. Bright), but they did not take much notice of his conception of his nervous system. His idea of vital forces even met with very sharp criticism from his contemporary, the great historian of medical sciences, KURT SPRENGEL, who reproaches him with a total lack of philosophic precision and subsequent confusion of ideas, and of treating the doctrine of the primary forces of the animal body in a way

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less than mediocre. But in spite of that criticism Prochaska's point of view was progressively adopted by the biologists and brought its fruit; and it is not unlikely that his widely used new textbooks contributed to it, at least in Austria and Germany. His work on the nervous system—although reprinted in his *Opera Minora* (1800)—was little known during his lifetime, or rather, its true value was not grasped until some years after his death. Until 1838 it was probably more read than quoted. We have mentioned the controversy between Marshall Hall and his contemporaries. George quoted Prochaska's texts extensively, and in 1839 ALEXANDER WALKER reprinted his chapter on *sensory communitas* with an English translation in his anonymous "Documents and Dates on Modern Discoveries in the Nervous System," and in 1851 the whole of the "*Commentatio*" was published in T. LAYCOCK's translation by the Sydenham Society. In France, he was extensively quoted and his contribution highly estimated by LONGET, in Germany by PFLÜEGER, in Austria by JEITTELES and NEUBURGER. JULES SOURY in his monumental work on the history of doctrines on the nervous system (1899) pays high tribute to the originality of the truly scientific approach which enabled Prochaska to formulate the first general theory of nervous action.

In this brief paper we cannot of course do justice to the whole of the work and all the achievements of this brilliant anatomist and, as we have seen, essentially modern physiological thinker. It sketches at least, we hope, the place he occupies in the history of medical science, which is, according to several authorities—Hyrtl, Longet, Pflüger, Souri, Neuburger, Fearing, etc.—quite an important one. Neuburger designates him as the forerunner of another great Czech physiologist, J. E. PURKYNĚ, and they have indeed many traits in common. As we have enjoyed the generous hospitality of this country during this great crisis in European history, it is of great interest for us to point out many links of his work with the British medical world. Prochaska continued in the pioneer work of the great British physiologists WILLIS and WHYTT and was inspired in his general scientific outlook by the ideas of NEWTON, which he was probably the first to apply to the method in biology. He was on the other hand a predecessor of Sir CHARLES BELL and MARSHALL HALL, and represents thus an interesting and important chapter in the medical relations of our two countries.

*Portrait: Frontispiece from Prochaska's *Disquisitio anatomico-physiologica organismi corporis humani ejusque processus vitalis, Vindobonnae*, 1812. By courtesy of the Librarian of the Royal Society of Medicine.